mice, a white or light yellow mouse on a black lava bed would be seen and captured before a black one.

One further fact must be taken into account in considering the adjustment of organisms to their environment, and that is that change of environment may well cause, and apparently has in the past often caused, the elimination of species over the whole extent of their area of destruction.

Consider how wide-spread must have been the consequences on the fauna of the northern hemisphere as far south as Long Island and even further south of the great ice sheets that covered the circumpolar territory in glacial epochs. Many poorly clad species of mammals must have found the icy conditions insupportable; just as the mastodon and mammoth did. The change in environment may be of a more subtle sort. Thus the great size and herd instincts of the bison enabled it to develop enormously on the extensive plains of North America and rendered it more than a match for the Amerinds living in a stone age. Just this size and number wholly unfitted these mammals for the new environment of the agressive, agriculturally inclined white man, armed with a rifle. Agriculture and free-ranging bisons could not coexist and the rifle eliminated the mammals. So today the great size and aggressiveness of the large mammals of Africa are a challenge to the sportsman and the future seems to spell extinction for them. Here we have to do with elimination resulting from what may be called a cultural evolutionary "mutation"—the rifle.

But man's part in evolution is not merely in the elimination of his large enemies, which he has all too thoroughly mastered, but in his struggle with the small and innumerable insects that threaten his agriculture as it becomes more intense. The more successful and prolific an insect injurious to agriculture is the more certainly will it arouse man's destructive energies and the greater the certainty that the all too favorable mutation that is the cause of its success will be the cause of its elimination in whole, or part.

But mutations of a still more dangerous sort are threatening mankind—mutations in the world of organisms that live as parasites on the human protoplasm. With the more conspicuous of these parasites, external and internal, man has learned to cope. One by one the pathogenic bacterial diseases are being eliminated or reduced in frequency. But now we face still smaller parasitic particles—the filterable viruses—which are, at present, practically inaccessible to man. There seems to be reason to conclude that they are mutating, also, and

perhaps rapidly. The waves of influenza epidemics that pass round the world in periodic fashion assume slightly different aspects—show somewhat different symptoms—in successive visits. Those who are resistant to the one visitation may show slight resistance to the next. The selections of the past have left the stocks of the more crowded continental areas a hardy resistant people—far more so than the peoples of distant oceanic islands that had not undergone selection for resistance to the ultra-microscopic parasites. When one contemplates the high mortality of the influenza epidemic of 1918 one realizes that notwithstanding this high resistance it is quite within the range of possibility that at some future time a mutation shall arise in these viruses such that no human protoplasm is protected against it or can protect itself against it. Then our boasted skyscrapers might become inhabited by bats and the safe deposit vaults of our cities become the caves of wild animals.

Whether or not this will occur in the future, the possibility brings home a realization of the fact that man is not merely looking on the process of evolution taking place around him but, as an organism, he is a part of that evolution; he is acting upon other organisms and being acted upon by them as well as by the inorganic world in which he lives. He is attempting a mastery of that world; and, indeed, upon such mastery his fate may depend. His ability to master that world depends upon his superior gifts of intelligence to see relations and to idealize new ones. How much farther man can go in this direction depends upon the capacity for development of the intelligence. There are those who warn us that we are approaching the limit and must sometime in the future wait for further human evolution to make further fundamental progress. To wait until nature affords the desired mutation may mean indefinite postponement. Can not man himself control his evolution? Two methods are open; one the production of new and better combinations of traits by appropriate matings. This is the method of the applied geneticist interested in creating new and improved varieties. This is the method that is open to man also, if only some change in the social order may make it feasible to apply our knowledge to the improvement of the genetical combinations in mankind.

But still another way may be opened in the future; that is the acceleration of mutation by irradiation. The method is fraught with tremendous difficulties. The commonest effect of irradiation of the gonads is the production of defective, often happily non-viable individ-

uals. Whether the production of scores of defective strains to secure one line with a superior mutation is justified will have to be considered. But if man is to evolve he must not decline to use nature's tools of mutation, cross-mating, selective elimination while he seeks to become fitted to meet the requirements of an ever changing and ever more-demanding environment.

To sum up, then, the mechanism of organic evolution, as I see it, consists of the following processes:—

1. Infinite capacity of the germinal material for reproduction.
2. Infinite capacity for mutation.
3. An infinitude of kinds of environments.
4. Extensive opportunities for dissemination of the mutant individuals over earth, permitting some of them to find an environment for which they are especially fitted.
5. As for the rest of the infinitude of individuals, non-mutant and mutant (beyond the number required for replacement) *elimination.*

In a sentence, nature's mechanism of evolution includes the elements of: an infinitude of kinds of environments, infinite reproduction, infinite mutation, infinite opportunity for new mutants to find appropriate environments and elimination of all of the infinitude of other individuals that are not required for replacement.

Homo sapiens is only a natural species with a highly evolved hand and brain. This species has reached its lofty position in evolution by the processes described. It is proud of its control of nature in certain directions. Let it beware lest it think it can evolve further by a man-made formula that may suit its perverted desires but must eventually fail of permanent progress if opposed to the formula of nature.

PALEONTOLOGY.—*Remarks on Dr. George G. Simpson's work on the Pleistocene paleonotology of Florida.*[1] OLIVER P. HAY, Washington, D. C.

Recently Dr. George G. Simpson, of the American Museum of Natural History, New York, has published a number of papers on the Pleistocene paleontology of Florida. They are important communications, and with the activity of this author and others now interested in this subject the paleontology of Florida must soon become much better understood. It is with regret that I must present some criti-

[1] Received May 12, 1930.

cisms on Dr. Simpson's conclusions. I shall be concerned especially with his paper entitled: The extinct land mammals of Florida,[2] and with another having the title: Pleistocene mammalian fauna of the Seminole Field, Pinellas County, Florida.[3]

In this latter paper Dr. Simpson discusses the correlation of he Pleistocene deposits; and he credits the present writer with having expressed the most definite opinions on the subject. He states that these opinions seem largely to rest on three assumptions, of which the following is the first: That each local fauna studied is actually an assemblage of contemporaneous mammals.

Dr. Simpson[4] says that this is illustrated in the case of the so-called Peace Creek fauna, "elements of which were largely derived from both Pleistocene and older deposits." My list of the mammals collected near Arcadia is found on page 381 of Publication No. 322 of the Carnegie Institution of Washington. Of that list of 15 mammals there is, I believe, only one, *Hipparion ingenuum*, whose Pleistocene age can be fairly questioned; and that this *Hipparion* may have continued on even into the Aftonian is again suggested by the recent discovery by Simpson[5] of the "three apparently Pliocene species *Hipparion ingenuum*, *H. plicatile*, and *Serridentinus* sp.," along Itchatucknee River, Florida, associated with Pleistocene fossils.

Dr. Simpson recalls also my reference[6] of the fossils of the Alachua clays to the Nebraskan stage. In this case there are involved *Gomphotherium floridanum*, *Procamelus*, two species of rhinoceroses, *Hipparion*, and *Parahippus*. Dr. Simpson declares these genera are certainly not younger than Middle Pliocene. Now I am willing to admit that I was probably wrong in this assignment; but for this action I gave my reasons; and, whatever the probabilities, nobody ought to express himself as certain that these genera, or some of them, did not continue on into the first glacial stage, where I put them. The Pleistocene climate of Florida has been inordinately extolled and it was probably as "congenial" during the last half of the Pliocene as it was later, or more so.

I am further supposed[7] to have nurtured the assumption that the Pleistocene mammalian sequence is certainly known, if only in part,

[2] State Geol. Survey, 20th Ann. Rept. **1929**: 229–279.
[3] Bull. Amer. Mus. Nat. Hist. **56**: 561–599. 1929.
[4] Bull. Amer. Mus. Nat. Hist. **56**: 569. 1929.
[5] Amer. Mus. Novitates **406**: 13. 1929.
[6] Carnegie Inst. Wash. Publ. **322**: 375–378.
[7] Bull. Amer. Mus. Nat. Hist. **56**: 568. 1929.

for other regions of North America, and "especially along the margins of the drift." This assumption Dr. Simpson grants is partially justified; and then he follows with a sequence that I wholly repudiate, —one which I have never before heard expressed. The first phase is said to embrace the time from the earliest Pleistocene to just before the close of the epoch. During this phase *Hipparion* was absent, "*Equus* occurred, tapirs and camels were present, and most of the smaller animals and all of the larger ones were of now extinct species."

Now, there was no such natural phase or stage of evolution or extinction. There was no known time in the Pleistocene, at least after the Nebraskan, when most of the smaller animals and all of the larger ones belonged to now extinct species. According to Simpson, some of the ground sloths and peccaries continued on into his second phase, and certainly he might have mentioned many other mammals. This phase was partly late Pleistocene, partly "post-glacial," which is Recent. What important biological or geological events happened to distinguish this phase from the first; and what occasion is there for recognizing a third phase which does not belong to the Pleistocene? And what authority has he for saying that no elephant, no mastodon, no tapir, no peccary, no ground sloth lived on into the Recent?

Cope is credited with contributing to this history of paleontology. Cope and Marsh and Dall instinctively avoided such an allocation of the faunas of the Plains, of Texas, and of Florida, and put them in the Pliocene, until G. K. Gilbert convinced them of their error. It was left for a younger generation to rush to the other extreme and to accept the doctrine that any Pleistocene animal may be found at any stage of the Pleistocene and in any locality.

Dr. Simpson's first phase occupied some 400,000 years and glided into his second and third phases without having ushered in any critical event.

I regard it as incontestable that any adequate assemblage of Pleistocene fossils collected anywhere outside of the glaciated regions, west or south, will contain a much higher percentage of extinct species and genera than will be found in any deposit overlying any drift after the Nebraskan. During the Kansan glacial stage is probably where a paleontological break occurs. The pre-Kansan fauna, varying somewhat with latitude, longitude, elevation and climate, embracing ground sloths, glyptodonts, megatheres, numbers of horses, camels, *Elephas imperator*, *E. columbi*, and *Stegomastodon*, extends from the Atlantic to the Pacific and from the Gulf to the south border of the

drift. As long as geologists, paleontologists and anthropologists stand on glaciated lands they are held down to definite periods of time, but once outside the drift deposits they feel free to refer any long-ago extinct animal to a time within a few hundred years, especially if its presence menaces the theory of the late appearance of man.

Dr. Simpson adds that it is especially along the margins of the drift that I believe that the mammalian sequence is known.[8] Quite the contrary. The drift sheets and the drift margins simply conceal the ancient fauna, the Aftonian, from view. In deposits lying on the Kansan drift, and Illinoian drift and the Wisconsin, from Cape Cod to the Rocky Mountains, are found the extinct members of the late fauna. In these deposits occur *Mylodon, Megalonyx, Canis,* bears, the American mastodon in abundance, *Elephas boreus* in abundance, one or two horses only, a few bison, peccaries, and possibly any species now living in the glaciated region; but so far as yet discovered, no megathere, no *Nothrotherium,* no *Glyptodon,* no long-jawed mastodon, no *Elephas imperator,* no *Stegomastodon,* no large number of species of horses, no camels. If the Kansan and succeeding drifts were swept away, the early fossils would probably come into view. For when you pass the margins of the drift sheets or even before, where erosion has cut down to the the first interglacial deposits, you are likely to meet with the forms not found on the drift.

I take no account of the margins of the drift, except to note that south and west of them occur remains of a very rich fauna containing a high percentage of extinct animals, while north of them is found, usually near the surface, a much more improverished assemblage of mammals. In western Iowa have been collected from first interglacial beds *Elephas imperator, Stegomastodon, Camelops,* and species of *Equus.* If now these forms continued to exist during later stages in that region, can anybody explain why they so carefully avoided leaving any traces of themselves in any glacial or interglacial deposit east of Missouri River, while leaving abundant records of their existence west of the river?

I am also said to assume that the sequence of mammalian forms was essentially the same in Florida as in other regions of North America. I have presented reasons for adoption of this view and nobody has yet undertaken to disprove my positions in a comprehensive manner. I do not see why Florida formed a special case.

[8] *Op. cit.*, p. 568.

In arguing against this so-called assumption, Dr. Simpson states that the Florida mammals, when well known, generally prove to be of different species from those of the north and west. When his list of land mammals of Florida, existing and extinct[9] is examined it is seen that 63 species are listed in the Pleistocene; 38 of these are animals found north and west of Florida; and 25 species peculiar to Florida. This amounts to 61 per cent of the mammalian forms that are found outside of Florida and 38 per cent that belong in Florida alone. It is doubtful if the peculiar forms occurring there are more numerous than would be found in any other region where the smaller species have been collected and studied; and no doubt many of these Floridian species will hereafter be discovered elsewhere. On studying Barnum Brown's list of fossils found in Conard fissure, Arkansas, I find little difference.

It is a pleasure to find that Dr. Simpson is so closely in agreement with me on the similar composition of all the collections that have been assigned to the Aftonian stage in Florida. We disagree only on the time of the deposition of these fossils. I hold that those animals were buried there during perhaps the whole of the Aftonian and perhaps a part of the Kansan stage; Dr. Simpson argues against the probability of this.

As regards the deposit No. 3, there may be indeed extraneous fossils in it. I was led to refer it to the Kansan stages because the geologists insisted that deposition had been continuous with bed No. 2, and this bed I hold is first interglacial. In No. 3 there are certainly both extinct and yet existing species, but it is hardly fair to declare the extinct species as having been derived from No. 2 unless there is evidence of that origin. Deposition went on very slowly during the formation of this bed and apparently during the whole Pleistocene in this region.

In his paper on the fossils of the Seminole Field[10] Dr. Simpson regards it as important that the Melbourne collections contain so many species quite indistinguishable from those still living in the same region. He finds no evidence in any group of more than subspecific advance from that time to this. In this observation he again supports what I have more than once asserted, namely, that since the Aftonian stage there has occurred little or no evolution of specific forms. And I am permitted by Mr. Gerrit S. Miller, Jr., associate curator of mammals in the U. S. National Museum, to say that he has seen no evidence

[9] State Geol. Survey **20**: 251.

[10] Bull. Amer. Mus. Nat. Hist. **56**: 571. 1929.

that during the Pleistocene there has been, among the mammals, any development beyond that of subspecies. If there has occurred since early Pleistocene times the rapidity of development of new species implied by Dr. Simpson, I ask him what kinds of mammals lived during the early Pleistocene and where they have been collected? My belief is that the Melbourne fossils are those early Pleistocene mammals and that our existing species lived at that time. I might be willing to admit that some early forms may have undergone some of the minute changes which we think justify new specific names, but which other persons might not recognize as sufficient. Evolution is a slow process.

Dr. Simpson states that it has been genera rather than species that have survived. That is true, for the simple reason that a genus usually embraces more than one species and as long as one of these survives the genus continues. He also thinks that it is very exceptional that all the species of a genus in an area as large as North America should become extinct simultaneously. I do not see why this may not have sometimes happened, especially in the cases of genera including few species.

On another page, Dr. Simpson grants[11] that as high as 70 per cent of the Melbourne mammal fossils belong to extinct species. Usually such a high percentage of extinct species is accepted as an evidence of antiquity. On the next page he claims that it is no solution of the question to say that this extinction took place between the early and middle Pleistocene rather than between the late Pleistocene and the Recent. However, no one has claimed that all that 70 per cent of extinction occurred during that early stage. Not all the extinct mammals found in the Melbourne beds became extinct at that Aftonian time; comparatively few of them. The others perished at various later times, even up to the Recent. The common mastodon and *Elephas columbi* and *Castoroides* and many others of that fauna continued on until after the last glacial stage. My contention is that some of the species, as *Elephas imperator* and the few camels and the saber-tooth tiger and *Megatherium* and *Chlamytherium* died out then, for they have never been found in deposits whose later age can be demonstrated. And it would be strange surely if all those species had lived on through three or four glacial stages and then perished without any adequate explanation. Now, can Dr. Simpson or anybody else say anything against this statement?

[11] *Op. cit.*, p. 570.

But that is exactly the doctrine that Dr. Simpson is supporting: That all the species of horses found in Florida, all of the tapirs, all of the great sloths of various genera; all of the armadillos, all the elephants and mastodons; all of the capybaras, all the bisons, and all the species of several genera of peccaries; all of these lived on until in the late Pleistocene or to the Recent and then, in a time geologically brief, were swept out of existence. This is not all. There are those who apply this late existence and rather recent extinction to these genera over the whole of North America. *Elephas imperator*, and the camels are reported to have lived possibly within a few hundred years.

At this point reference may be made to Dr. Simpson's statement in his foot-note on *Bison*.[12] I am unaware who has so positively asserted that the occurrence of an extinct species of *Bison* is indicative of an early Pleistocene age.

It seems necessary to discuss again the climate of Florida during glacial stages. Dr. Simpson adheres to the idea that this state furnished an asylum where obsolescent groups survived beyond the time of those farther north. I have considered the statement that the climate of Florida has been more favorable for animal life than the northern states.[13] I have shown that the state of Illinois has harbored within historical times quite as many species of mammals as Florida; while the mountainous region of Colorado has offered an asylum to a considerably greater number than Florida.

Some of our vertebrate paleontologists appear to have evolved their theories of the glacial stages from the depths of their unaided consciousness, instead of from the writings of geologists and explorers and from personal exploration. On page 485 of Chamberlin and Salisbury's *Geology* is a fine discussion of the climatic conditions in front of a continental glacier. Further definite information can be secured from an examination of Pirsson and Schuchert's glacial map on page 945 of their *Text Book of Geology*. There it is shown, that, at some time, or at some times, during the Pleistocene, local glaciers far more extensive than those of the Recent epoch occupied the great range of the Andes, even on the equator; also in the Himalayas, and on the equator in Africa. It is evident that during a glacial stage the temperature of the whole world was lowered. It is evident, too, that in front of the continental glacier there was an arctic climate; farther away, a subarctic, a subtemperate, etc., each extending south for hundreds of

[12] *Op. cit.*, p. 569.

[13] THIS JOURNAL **19**: 469. 1929.

miles. That map ought to bring conviction to even those paleontologists who were the promoters of the idea that in Iowa, during the Nebraskan or the Kansan stage, camels, elephants, ground sloths, horses, and musk-oxen lived together in the immediate front of the glacier. It has been suggested that at least these animals migrated thither during the warm summers; but on what food did they appease their appetites? Did they all alike subsist on rock-lichens and moss?

The writer does not object to the most complete investigation of the geology and paleontology of Florida; but that alone will probably not furnish a solution of the age of the Melbourne fauna. The problem is a more general one. The mammals of North America during the Pleistocene did not consist of three, or even more, distinct assemblages occupying different tracts of the continent. They were of triple origin, but they formed one faunal assemblage. This varied somewhat in composition according to temperature, moisture, kind and abundance of food, the stage of the epoch, and the like, but there were almost everywhere many genera and not a few species which ranged from the Atlantic to the Pacific, and from the Aftonian to the close of the Wisconsin. There were also subregions, occupied by peculiar genera and species, as there are today.

On the other hand, there was one wide-prevailing cause of disaster which operated at four or five times simultaneously on this whole assemblage of mammals. This was the occurrence of continental glaciations and the consequent lowering of the temperature, disturbance of weather conditions, general expatriations and repatriations of the mammalian inhabitants, and the extinction of many important genera and species.

If the glacialists are correct in their conclusions, the arctic climate was transferred at one time from its present limits to the Ohio River at Louisville, a distance of about 1,600 miles. From this border to central Florida is about 800 miles. We know that at our own day winter storms penetrate this interval and produce severe damage on vegetation and doubtless on animals also; but how much more injury and suffering and death must have been inflicted by storms starting over the ice fields at a high elevation, and sweeping as far south as Florida.

Dr. Simpson describes[14] a species to which he assigns the name *Boreostracon floridanus*. He also gives an abstract of the discovery and naming of previously collected materials which were referred to

[14] Bull. Amer. Mus. Nat. Hist. **56**: 581. 1929.